NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 3549

FLIGHT INVESTIGATION AT MACH NUMBERS FROM 0.8 TO 1.5 TO DETERMINE THE EFFECTS OF NOSE BLUNTNESS ON THE TOTAL DRAG OF TWO FIN-STABILIZED BODIES OF REVOLUTION

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Washington
December 1955

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FLIGHT INVESTIGATION AT MACH NUMBERS FROM 0.8 TO 1.5 TO DETERMINE THE EFFECTS OF NOSE BLUNTNESS ON THE TOTAL DRAG OF TWO FIN-STABILIZED BODIES OF REVOLUTION[1]

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SUMMARY

Values of total-drag coefficient were measured for two fin-stabilized, blunt-nose bodies of revolution in free flight at Mach numbers from 0.8 to 1.5. The blunt-nose configurations were designed by rounding off the sharp noses of two previously tested configurations, having nose fineness ratios of about $3\frac{1}{2}$, to radii equal to about $\frac{1}{4}$ the maximum body radii.

By comparing the measured values of drag coefficient based on frontal area for the blunt- and pointed-nose models, it is found that, within the accuracy and range of the present tests, rounding off the sharp noses produced no increase in the total drag of either configuration.

INTRODUCTION

The NACA has conducted an investigation to determine the drag of practical fuselage shapes at transonic and supersonic speeds. One phase of this program is an investigation of how changes in nose shape affect the drag of an airplane or missile configuration. Linearized theory (ref. 1) and some experimental data (ref. 2) have indicated that, for minimum drag at supersonic speeds, the fuselage-nose profile must be of high fineness ratio and tapered to almost a point at the vertex. It is of particular interest to determine how far practical designs can deviate from such profiles without severe reductions in speed and range.

In the present paper, drag data are presented for fin-stabilized bodies of revolution whose noses, originally pointed and of fineness

[1]Supersedes declassified NACA RM L50I08a, 1950.

ratios 3.56 and 3.50, have been rounded off to radii equal to 0.274 times the maximum body radii. Also included are drag data from reference 3 on a body of revolution which was similar to one of the present bodies but had its nose rounded off to a radius equal to 0.776 times the maximum body radius.

The tests were conducted at the Langley Pilotless Aircraft Research Station at Wallops Island, Va., by means of rocket-propelled models.

MODELS AND TESTS

The general arrangement of the test configurations is shown in figure 1, and photographs of the test vehicles are shown in figure 2.

Configuration (a) was adapted from a parabolic body of revolution having fineness ratio 8.91 and maximum diameter located at 40 percent of the body length. Table I lists values of body radius at a number of stations along the pointed-nose parabolic reference body.

Configuration (b) was adapted from the wingless body of reference 4, which was a body consisting of a fineness-ratio-3.50 ogival nose joined to a cylinder at 31.8 percent of the body length. Values of body radius at a number of stations along the pointed-nose ogive-cylindrical reference body are listed in table II.

Configurations (a) and (b) were adapted from their corresponding reference bodies by replacing the nose point with a spherical segment of radius equal to 0.274 times the maximum radius of the reference body. The spherical segment and the unmodified portion of the nose are tangent at the station where they meet, and the profile slope is continuous. Behind this station, configurations (a) and (b) are identical to their respective reference configurations.

For model (a) the frontal area was 0.307 square foot, the base area was 0.0586 square foot, and the exposed fin area was 1.69 square feet. The unmodified body length was 66.81 inches. Model (a) was stabilized by three 45° sweptback fins located so that the trailing edges intersected the body at a position corresponding to station 60.5 on the unmodified body. Measured in the streamwise direction the chord was 9 inches and the thickness ratio was 0.0278.

For model (b) the frontal area was 0.1364 square foot and the unmodified length was 55.06 inches. The model was stabilized by four fins having a total exposed area of 0.949 square foot. The fin plan form was tapered from an 8.38-inch root chord to a 1.38-inch tip chord.

Except for the rounded leading edges, fin sections were rectangular and measured 0.091 inch in thickness. The leading edges were sweptback 45° and intersected the body at station 46.44.

The fuselages were of wood, sanded and finished with clear lacquer to form a smooth and fair surface. The fins were of polished duralumin.

Both models employed a two-stage propulsion system consisting of a 3.25-inch aircraft rocket motor as the sustainer unit and a 5-inch high-velocity aircraft rocket as the booster unit. The booster unit was stabilized by four fins and was attached to the sustainer motor by means of a nozzle-plug adapter.

Test data were obtained and reduced by the methods described in reference 4. Drag coefficients have been based on body frontal area and represent the total drag of the configuration including interference drag.

The flight tests covered a range of body-length Reynolds numbers from 15×10^6 to 60×10^6. The Reynolds number encountered in flight is plotted against Mach number in figure 3.

The methods by which the present data were reduced were such as to introduce no errors larger than the scatter in the data points for an individual model or the discrepancies among the faired curves for models of the same configuration. The reliability of the data presented in figure 4 can best be judged by noting the amount of scatter in the points for each of the models and the small differences in trend of the data for the two models of the parabolic reference configuration.

RESULTS AND DISCUSSION

The results of the present tests are given in figure 4, where total-drag coefficient based on body frontal area is plotted against Mach number for the configurations tested. Values of drag coefficient are presented for two models of the parabolic reference configuration. Drag-coefficient values for the pointed-nose ogive-cylindrical configuration were obtained from reference 4.

Also included in figure 4 are drag data from reference 3 for an ogive-cylindrical configuration having its nose rounded off to a radius equal to 0.776 times the maximum body radius. The body of reference 3 had thicker fins and a slightly different base than the ogive-cylindrical body used in the present tests. In order to make those data directly comparable to the present results, the incremental-drag-coefficient values added by the spherical nose were obtained from the data of reference 3 and added to the drag coefficients of the present pointed ogive-cylindrical models.

In figure 4 it can be seen that rounding off the nose of the parabolic body had no appreciable effect on the total-drag coefficient of that configuration. Rounding off the nose of the ogive-cylindrical body to a radius equal to 0.274 times the maximum body radius had no appreciable effect on the total-drag coefficient at Mach numbers above 1.05. At lower Mach numbers the drag was somewhat reduced. Rounding off the same nose to a radius of 0.776 times the maximum body radius increased the total-drag coefficient at Mach numbers greater than 1.03. The increase amounted to almost 60 percent of the total drag of the pointed-nose configuration at Mach number 1.3.

The effects of nose bluntness have been considered by several authors (refs. 1, 5, and 6) for the purpose of determining theoretically the nose of minimum wave drag for a given fineness ratio. On the basis of those considerations, the flow over the noses of configurations (a) and (b) may be described qualitatively.

At the nose apex the flow reaches stagnation pressure after having passed through a normal shock. The flow then undergoes a rapid expansion, reaching pressures below free-stream static pressure before leaving the circular profile. On the unmodified portion of the nose, the flow tends to approach the conditions which would exist on the pointed-nose body (except for small differences due to shock losses). The drag data for these configurations indicate that the effect of the higher pressures acting on a small area surrounding the apex is approximately canceled by the effect of lower pressures acting on a larger area to the rear.

CONCLUDING REMARKS

The effects of a moderate degree of nose bluntness have been investigated for two fin-stabilized bodies of revolution having somewhat similar nose profiles but differing in afterbody shape and fin configuration. No increase in the drag of either body was found. Results of a previous test show that a larger degree of nose bluntness can greatly increase the drag. An investigation of intermediate degrees of bluntness thus appears needed.

Langley Aeronautical Laboratory,
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Langley Field, Va., September 7, 1950.

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TABLE I.- PARABOLIC REFERENCE-BODY COORDINATES IN INCHES

Station	Radius
0	0
2	.54
4	1.04
6	1.50
8	1.91
10	2.28
12	2.61
14	2.90
16	3.15
18	3.35
20	3.51
22	3.63
24	3.71
27	3.75
30	3.74
33	3.70
36	3.64
38	3.58
40	3.52
42	3.44
44	3.36
47	3.21
50	3.04
53	2.84
56	2.62
58	2.47
60	2.30
62	2.12
64	1.93
66.81	1.64

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TABLE II

OGIVE-CYLINDRICAL REFERENCE-BODY COORDINATES IN INCHES

Station	Radius
0	0
1.00	.25
2.00	.48
3.00	.71
4.25	.99
5.00	1.15
7.50	1.58
10.00	1.96
12.50	2.26
15.00	2.44
17.50	2.50
55.06	2.50

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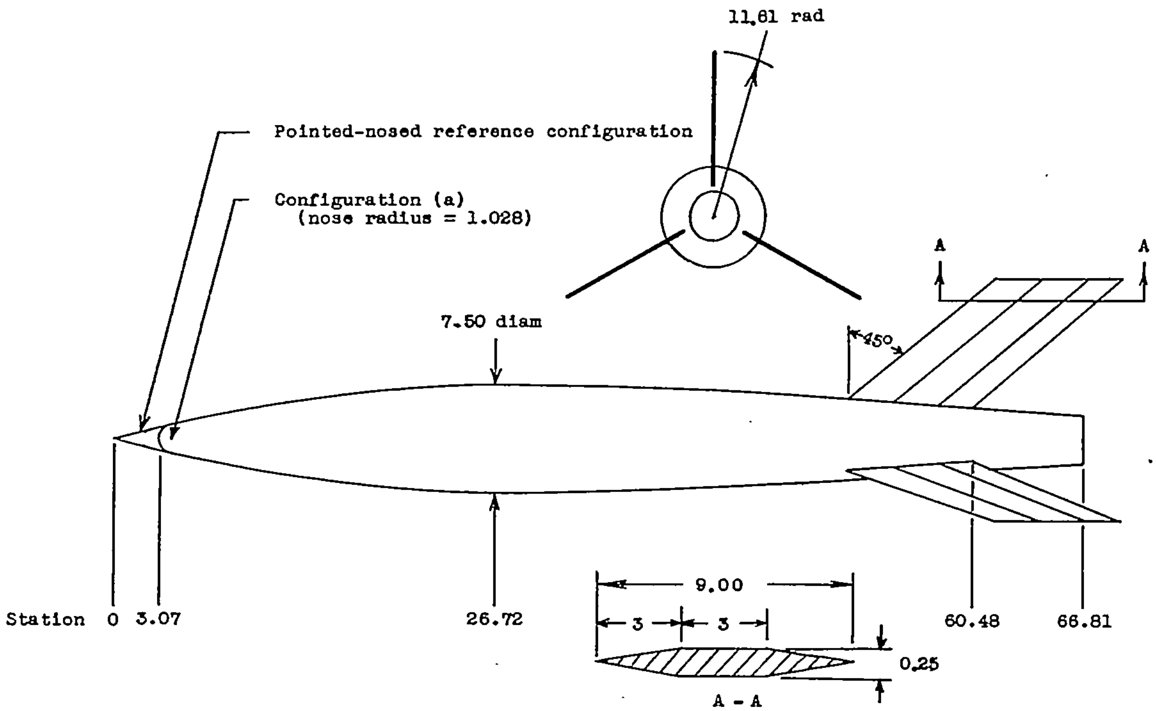
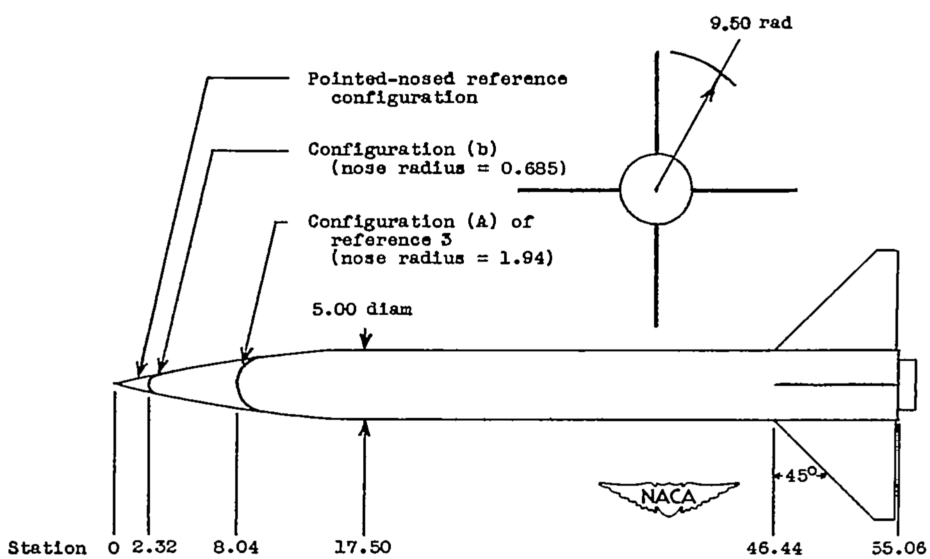
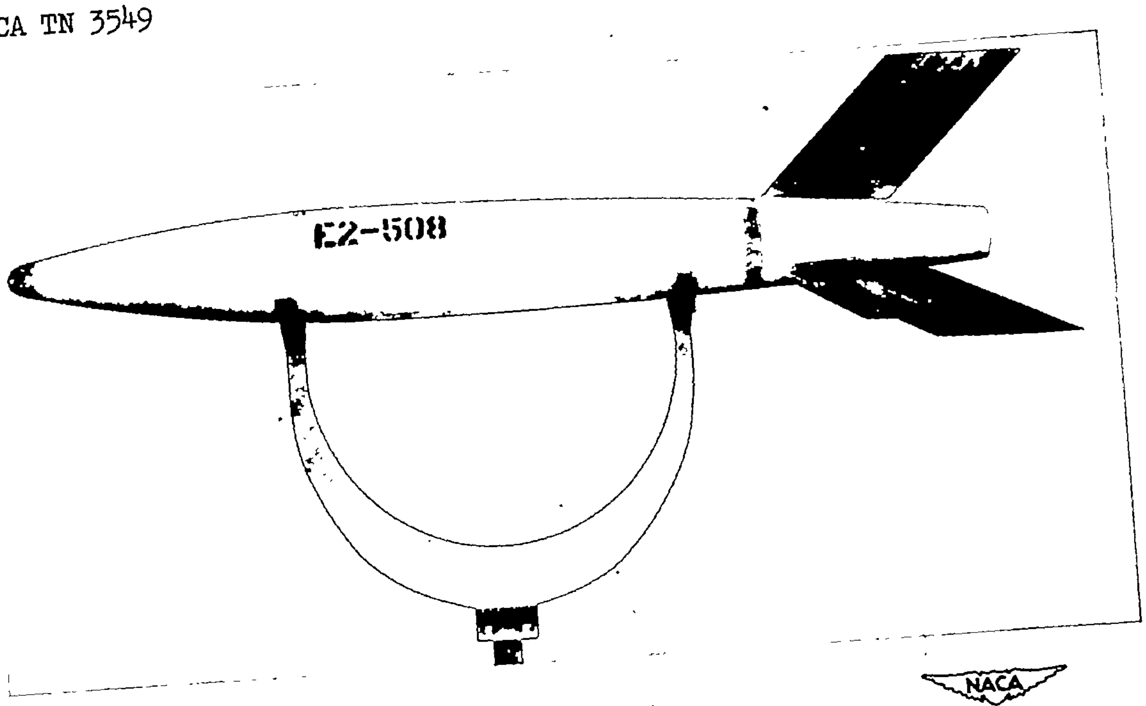


(a) Parabolic bodies.

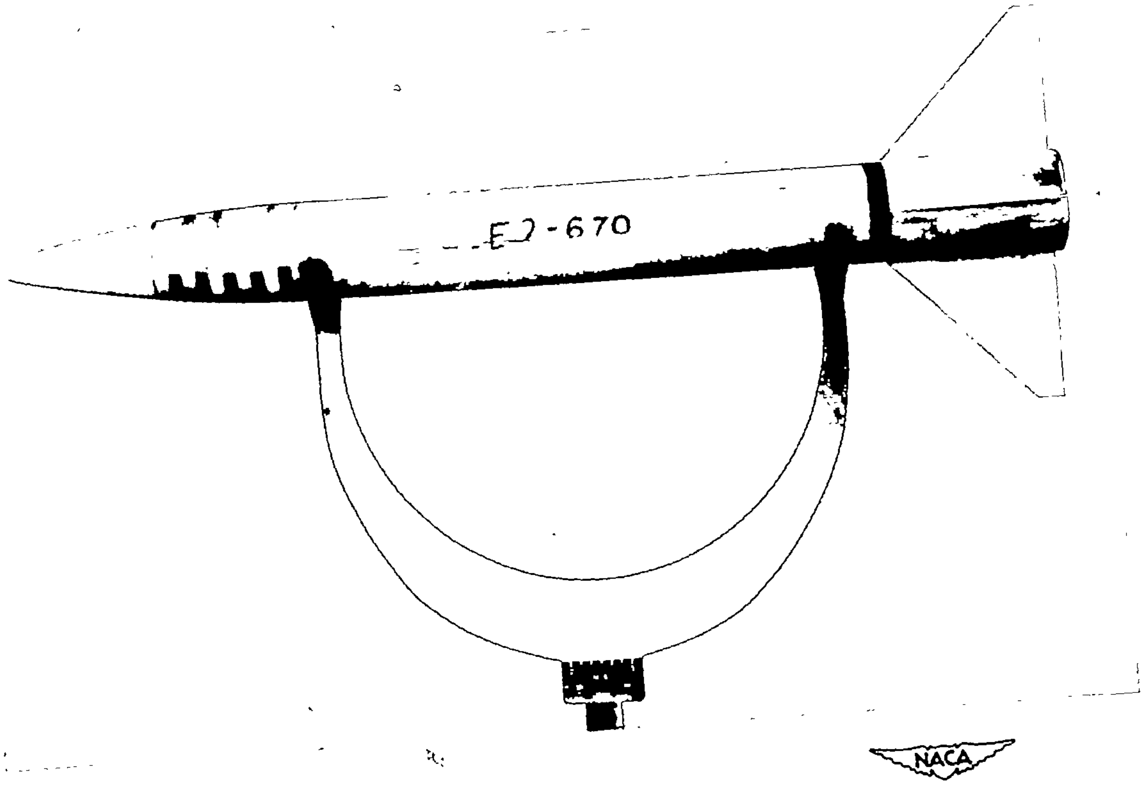


(b) Cylindrical bodies.

Figure 1.- General view of test configurations. Dimensions are in inches.



Model (a)
L-65930



Model (b)
L-65931

Figure 2.- Parabolic and ogive-cylindrical test vehicles.

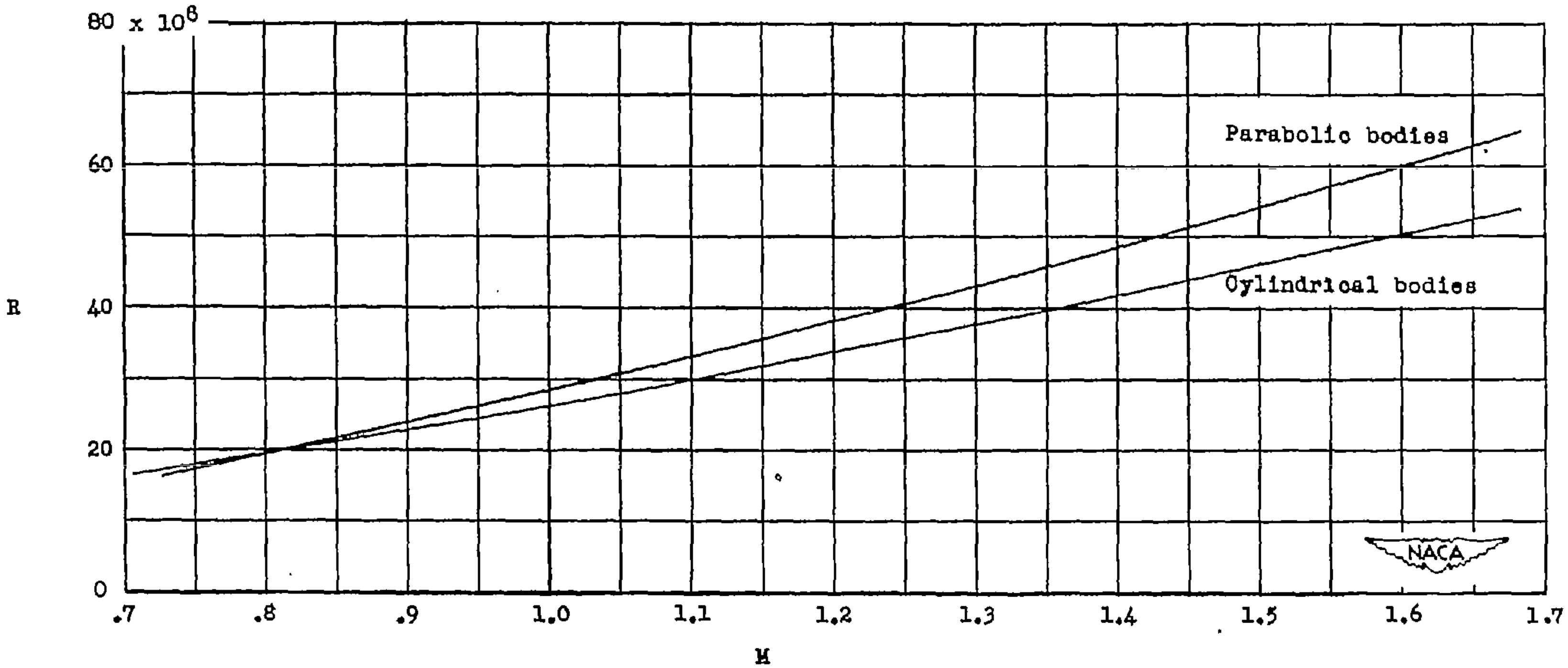
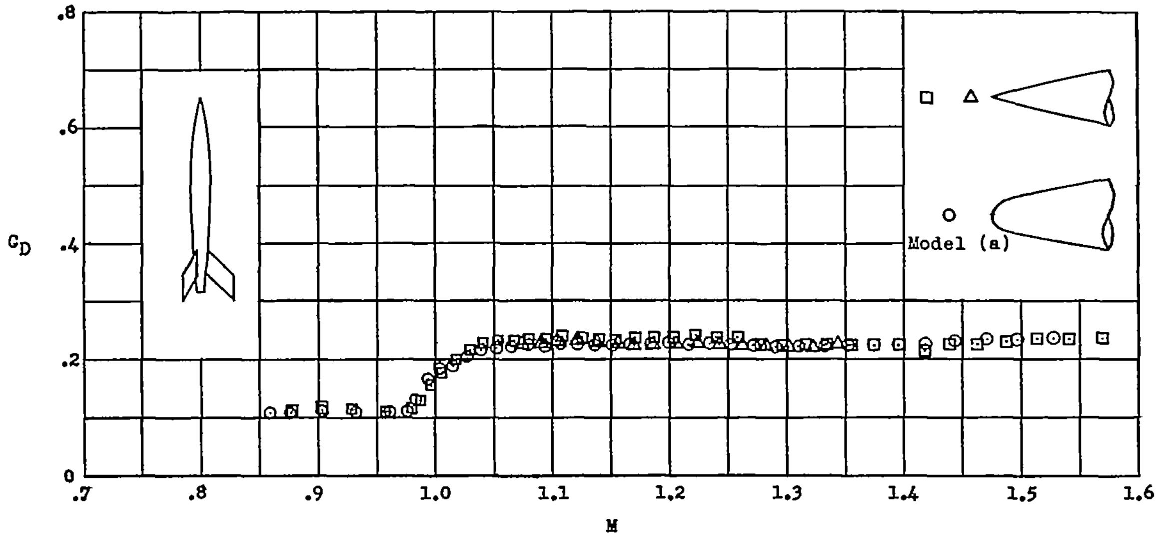
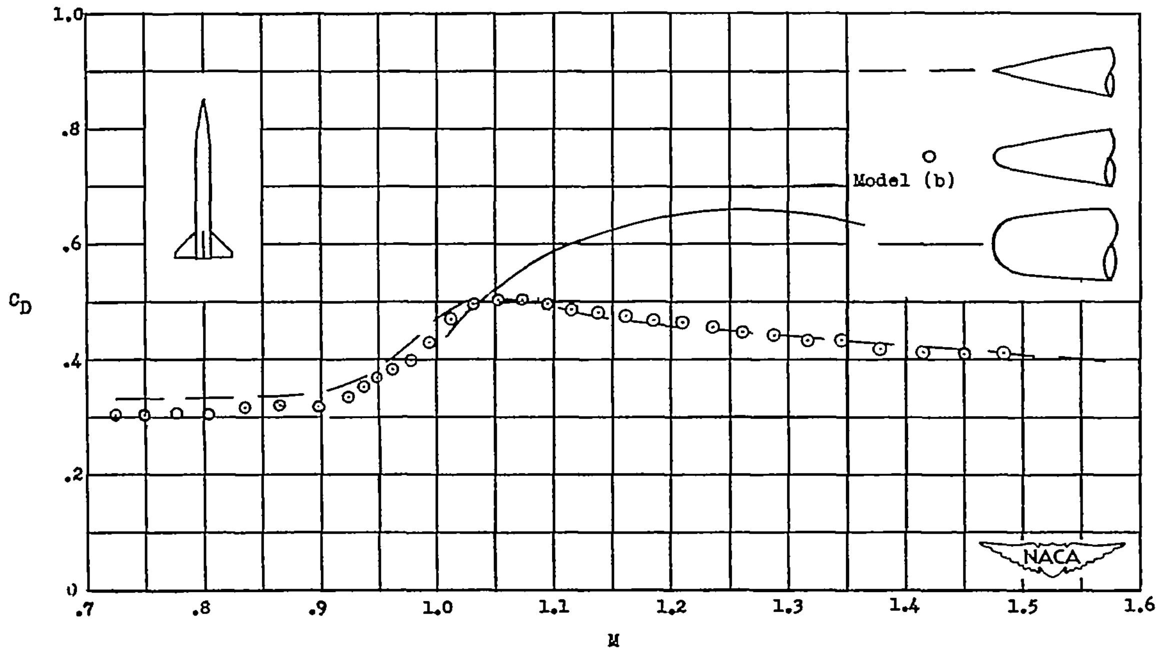


Figure 3.- Body-length Reynolds number R plotted against Mach number M. The curves represent flight conditions.



(a) Parabolic bodies.



(b) Cylindrical bodies.

Figure 4.- Drag coefficient C_D plotted against Mach number M for the configurations tested, for configuration A of reference 3, and for the pointed-nose reference configuration.